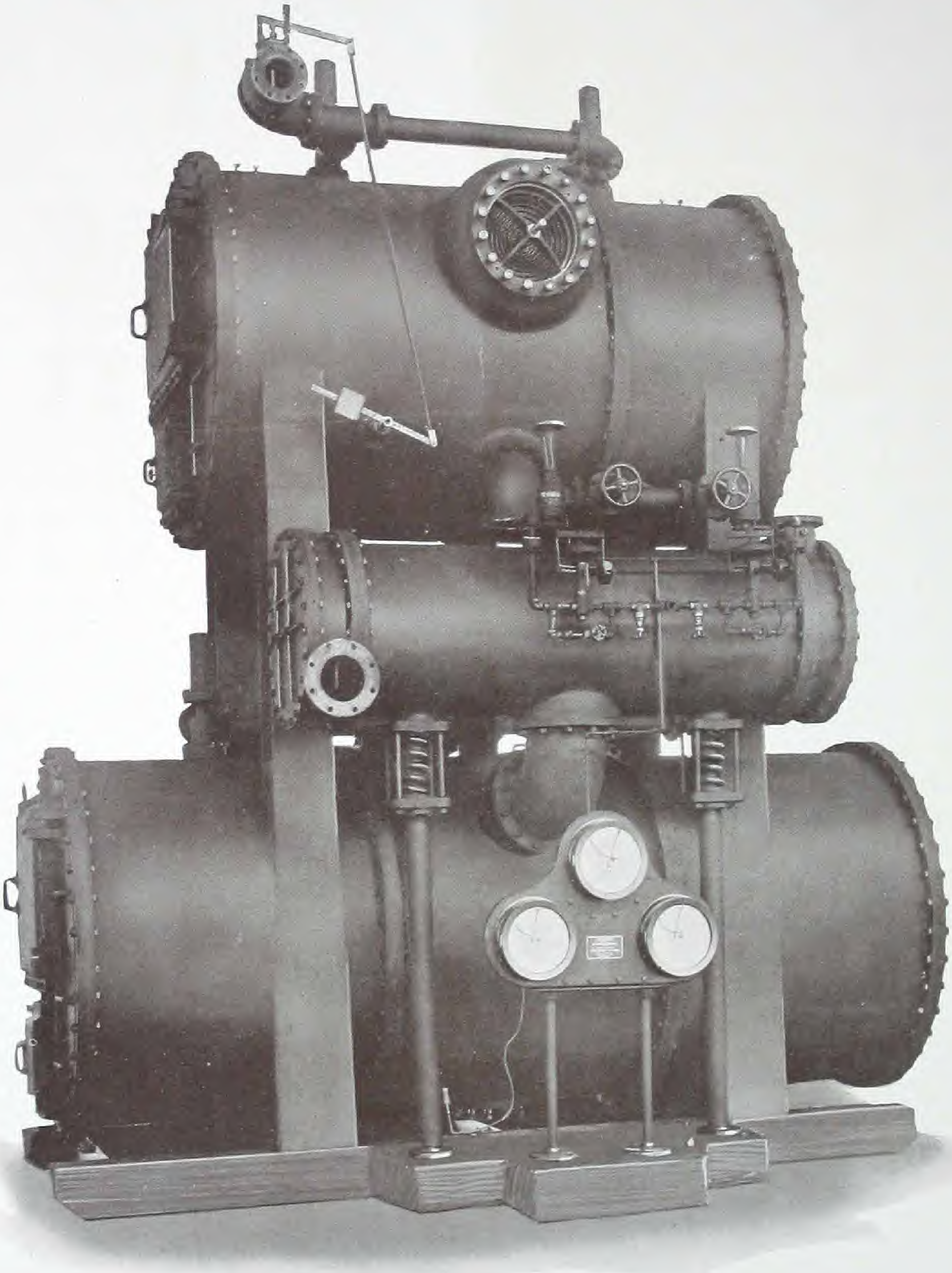
Conquering Corrosion

How Deaerated Water Protects Pipe Lines, Economizers, Boilers, etc. by removing the cause of corrosion.

BULLETIN N-4

ELLIOTT COMPANY
PITTSBURGH, PENNSYLVANIA
GENERAL SALES OFFICES, JEANNETTE, PA.



Typical Elliott Deaerator for Power Plant Service

Conquering Corrosion

A Review of the Corrosion Problem

CORROSION has always existed in water lines, but within the last decade, it has become a menace of extreme importance. Water, the universal commodity, necessary in all industrial operations, has been employed to an ever-increasing extent. Boilers now evaporate three to four times the quantity of water of former years; it has been found possible to operate them at these high ratings and secure the economy of a larger return upon the investment. Modern living standards and the increasing density of population, have placed very much heavier consumption upon water lines supplying buildings, apartment houses, etc. This larger use of water adds to the efficiency and comfort of modern life, but it is accompanied by an increase in corrosion difficulties which is proportional to the greater quantities of water handled. It is not surprising then, to find calculators estimating the annual economic loss due to corrosion of piping in the hundreds of millions of dollars.

In attempting to solve the corrosion problem, the use of metals supposedly resistant to corrosive action, has been advocated. Such a remedy cannot be anything but make-shift, because it has ignored the fundamental step in the solution of any problem—the finding of the cause. If it is possible to remove the cause of corrosion, is it not much better to do that than to let the destructive force continue to be exerted and try to limit its ravages? Corrosion in pipe can be entirely eliminated.

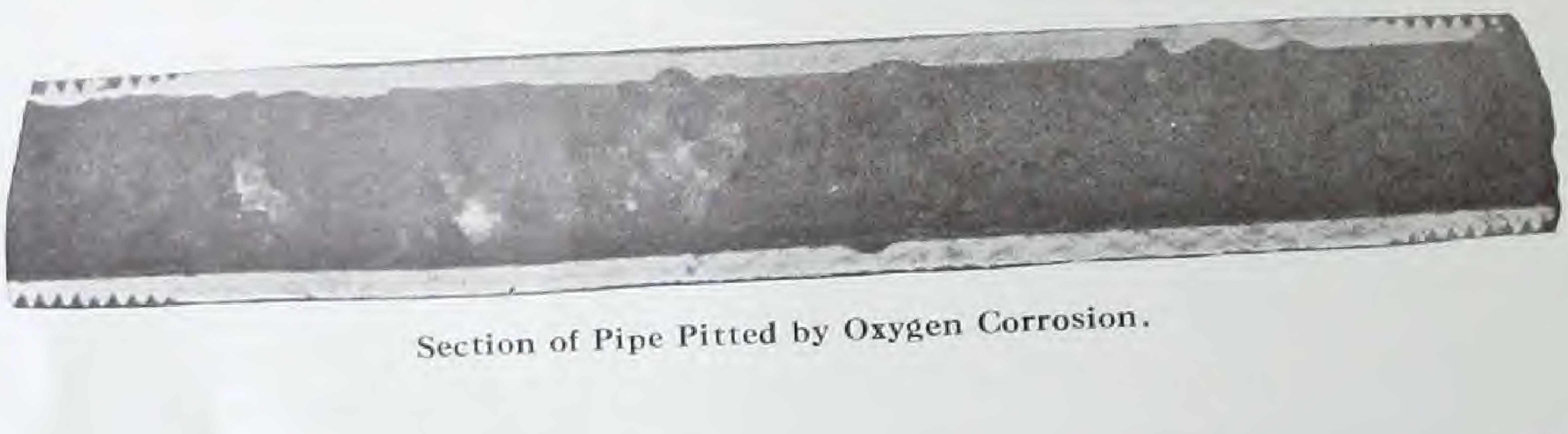
It has been demonstrated universally and upon all classes of water, that the removal of dissolved gases absolutely prevents corrosion. This is in line with the many theories that have been advanced as to the cause or causes of corrosion: for these theories, while differing in minor detail, may be summed up in a non-technical, but highly accurate manner, in the statement that corrosion in water lines results where *oxygen, water* and a *metal* are present, and the metal is not a noble metal (gold, silver, platinum). Water alone will not cause pipe corrosion. It must contain dissolved oxygen. With the oxygen removed, corrosion stops, provided the water is not essentially acid. Here, then, is the key to the whole situation. The solution for the problem of preventing corrosion reduces itself to this: "Remove the oxygen" by "Deaerating" the water. The process of removing the dissolved air (including oxygen, nitrogen and carbon dioxide) has been termed Deaeration.

Theory has pointed the way towards this pipe protection, but practice has demonstrated on a large and extensive commercial scale that the theory was fundamentally right and that the removal of dissolved gases constitutes complete protection. Elliott Deaerator installations speak for themselves.

Some Corrosion Specimens

Corroded Elbow and Nipple Showing Corrosion Products Removed.

Section of Pipe Showing Building Up of "Barnacles."



Section of Pipe Pitted by Oxygen Corrosion.

Section of Pitted Pipe From a Brooklyn Hotel.

Corroded Tube from Fire Tube Boiler.

Corroded Pipe Nipple Showing Stoppage of Pipe Area Due to Corrosion Products.

Protecting Water Lines

EVERYONE is familiar with the effects of corrosion in lines carrying water. When water flows rusty red from the pipes, it is the danger signal which indicates rusty, choked pipes. The rust-colored water stains linen and porcelain fixtures, wastes soap, irritates tenants and, in hotels and apartment houses, is the reason for the wasting of enough hot water to pay overhead and operating charges on a Deaerator. Deaerated water flows from the pipes clear and attractive.

In iron and steel pipes using raw water the products of corrosion grow and expand rapidly, remaining in the pipe and stopping the flow. The oxides formed in the corrosion of iron have many times the volume of the metal itself and also form excellent binders for conglomerating the scale-forming materials in the water. Corrosion products, when analyzed, show usually about 30% lime compound and 70% iron oxides, the oxides being predominately ferric, but usually containing some ferrous also. Ferrous oxide or its hydroxide in solution is soluble, while the ferric hydroxide is insoluble. The latter is the really dangerous product, producing stoppage of pipe lines. The extent to which these oxides are formed in relative proportion, is determined by the amount of dissolved gases in the water. Without deaeration, the ferric hydroxide is formed in the pipe and it is speedily obstructed. When deaerated water is used, however, ferric hydroxide slowly but surely is reduced to ferrous and as a result, corrosion products become soluble and pass out with the water.

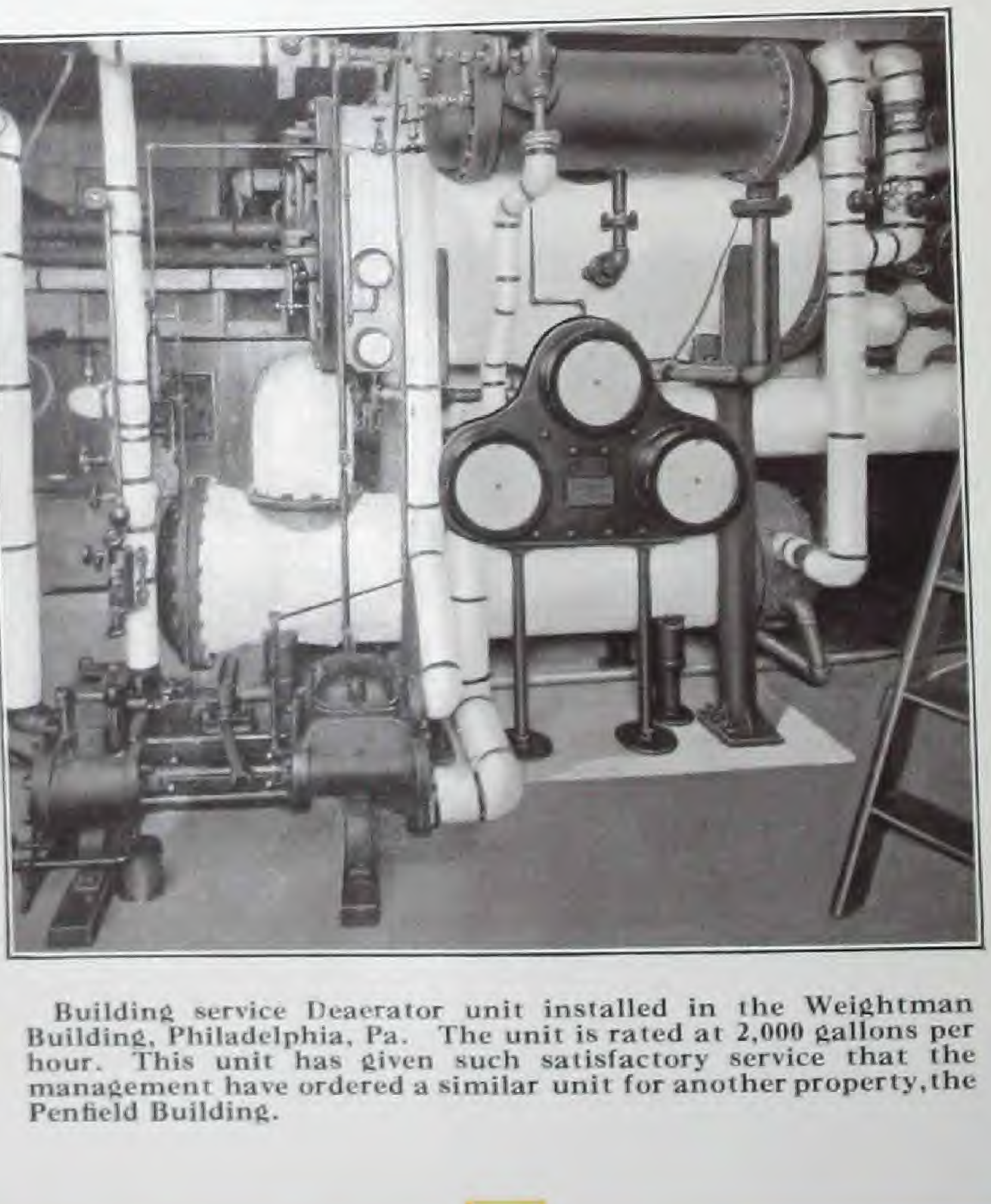
Deaerated water, therefore, has the property of working out of the piping system, the products of corrosion accumulated therein. It thus is capable of repairing damage already done. It cannot replace the pipe metal, which may have been eaten out, but it can do a most effective job of pipe cleaning and restore original water handling capacity, at the same time positively stopping corrosion and assuring that no further pipe clogging will occur as long as deaerated water is used. While this is not the fundamental advantage of deaeration, it is a most important one, for in certain localities, the stoppage of the pipes has been more of a limiting factor on the life of the pipe than actual perforation by pitting. As long as pipe lines are not actually perforated, they may be restored and protected by the use of deaerated water and the heavy expense of replacing them, in order to get proper water handling capacity is avoided. Still another advantage of keeping a pipe line clear is the avoiding of increased pumping charges to supply necessary water through choked pipes, with accompanying high pumping pressure, which puts additional strain on pipe already weakened by pitting and corrosion.

Iron and steel pipe usually fail through pitting, the pit holes starting in some dissolved or imbedded impurity in the metal surface and con-

tinuing indefinitely on account of the dissolved oxygen in the water, until perforation of the pipe ensues. Wrought iron and steel exhibit different allocation of the pit holes and the shape of the holes definitely determines the character of the material. Each material, however, has approximately the same useful life in hot water service.

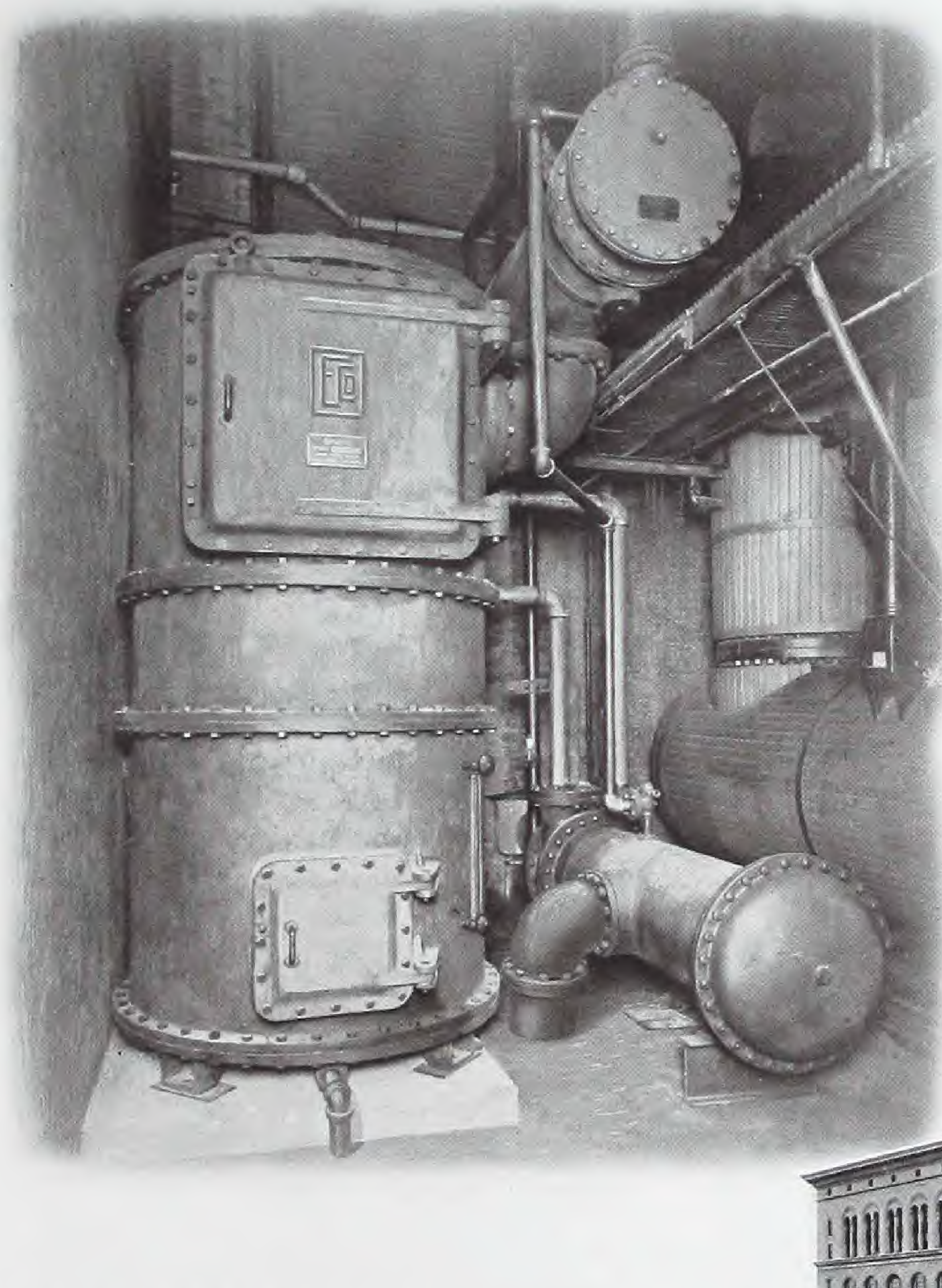
Brass pipe gives a little longer life than iron but its failure is due to eating out of some of the alloy ingredients in the brass and selective solution. Usually selective solution appears where the pipe has been subjected to mechanical strains and the pipe usually fails at the threads. The characteristic failure is partly evidenced by wasting away of the material and partly by a change in appearance of the brass, the color turning to a dull red and having the general appearance and mechanical characteristics of electrolytic copper. Brass pipes, ordinarily do not become obstructed unless the water contains iron or manganese in small quantities.

In considering the piping for a new building, it should be remembered that the use of deaerated water will easily make the piping last as long as the building itself, constantly saving plumbers' bills, repairs to the piping and fixtures and the losses due to tearing into walls and ceilings to replace rusted-out pipes. Further, since deaerated water removes the cause of corrosion, a saving can be made in the piping installation, since, with the power of the water to attack the metal removed, iron and steel pipe is just as good as brass or copper from a corrosion standpoint.



Building service Deaerator unit installed in the Weightman Building, Philadelphia, Pa. The unit is rated at 2,000 gallons per hour. This unit has given such satisfactory service that the management have ordered a similar unit for another property, the Penfield Building.

Deaerated water in building installations not only protects the hot water lines, but likewise the boilers and heating systems. The pipes in heating systems, operating under low pressure, are subject to air binding, blanketing of surface and water hammer, producing inefficiency and disagreeable noises and usually such lines show serious corrosion. All of these troubles are capable of correction by the elimination of dissolved gases from the water by the Elliott Deaerator method.



John Wanamaker Store

Philadelphia, Pa.

8,000 gallon building service unit

INSTALLATION of 8,000 gallon per hour building service type Deaerator. in plant of John Wanamaker Store, Philadelphia (illustration at right). The Separator is vertical, with Condenser above and closed heater below.

Protecting Boilers and Economizers

IN power plants, corrosion troubles are experienced in boilers and piping, especially in high pressure boilers, carrying from 200 to 300% overload. There is a tendency at present to employ high pressures on boilers and to operate them at very high ratings. The use of high pressures imposes a high exit flue gas temperature, due to the high steam temperature, making the use of an economizer for further heat recovery very desirable. With combined boiler and economizer units, the evaporating of large quantities of water produces an accompanying increase in corrosion.

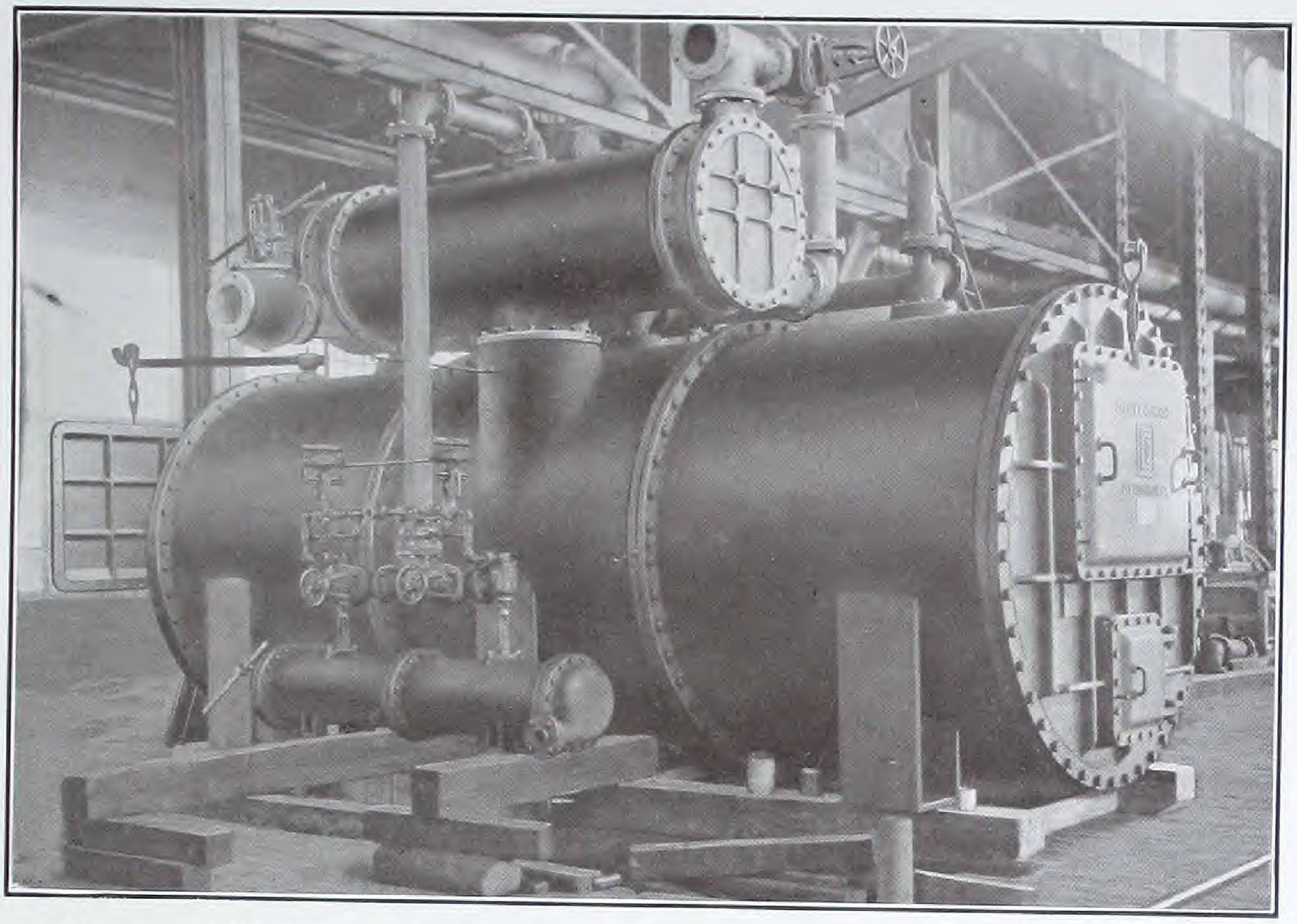
Where economizers are used in boiler plants, they have shown serious corrosion. The cast iron economizer has, because of uncertain factors of safety with high steam pressures, almost outgrown its usefulness. Cast iron economizers were never entirely immune from corrosion, particularly where it was necessary to clean them mechanically or where the water contained either chlorides or nitrates.

The use of high pressures has brought steel tube economizers forward as more desirable in producing higher efficiency within limited volume than the cast iron economizers and having in addition, a very definite factor of operating safety. The steel tube economizer, however, without the protection of deaeration, has a useful life so short that it does not constitute a profitable investment. In some cases tubes have been destroyed in a few months. Deaeration, by positively eliminating the cause of corrosion, has made the use of steel economizers practical.

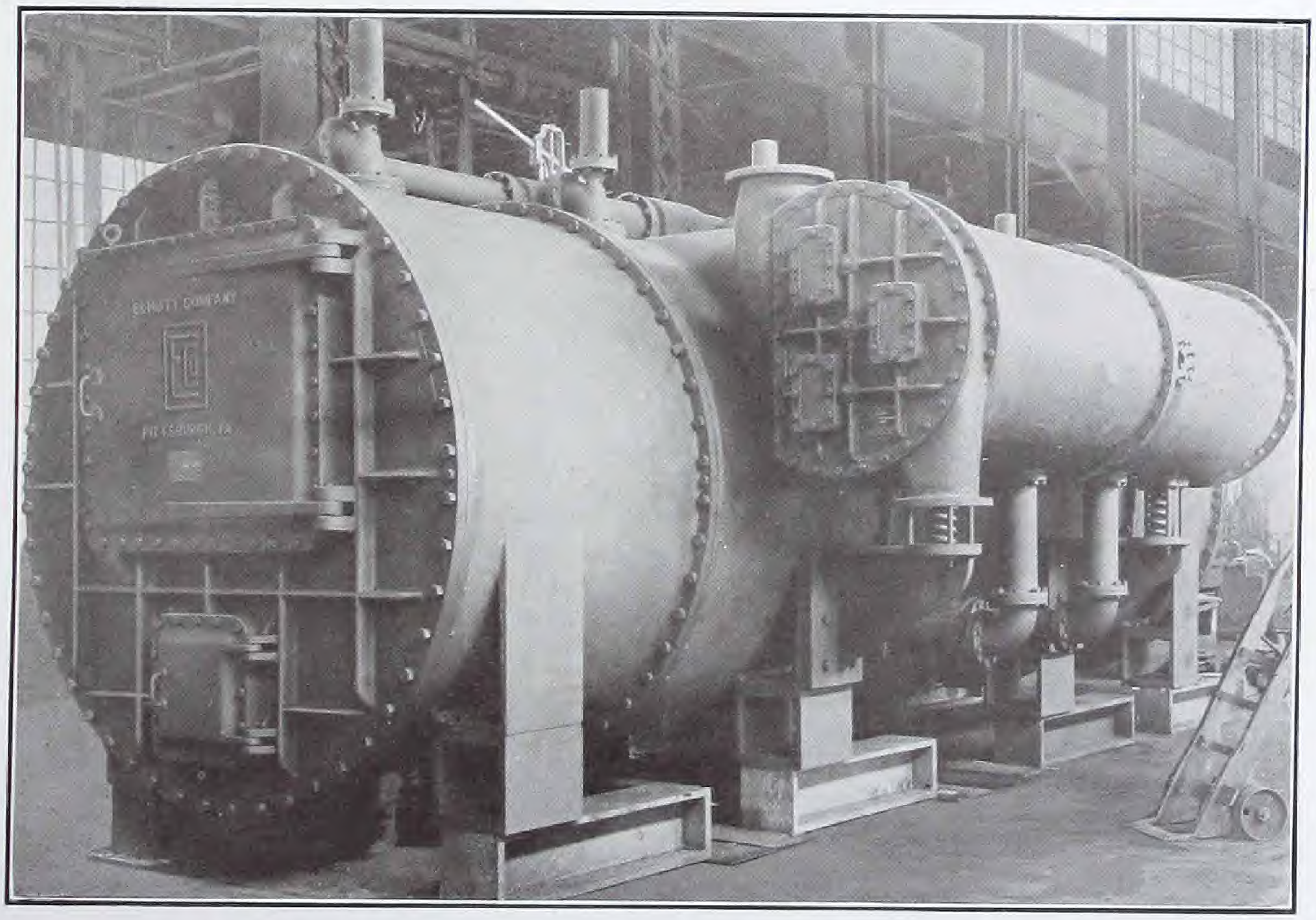
Elliott Deaerators have been in use long enough to demonstrate conclusively, that corrosion in steel tube economizers can be absolutely prevented. In a large number of modern power plants, it has been found possible to operate steel tube economizers and boilers for weeks at a time with deaerated water and to find on opening the drum, that the only corrosion observable was that due to drying off of the sheets and tubes in contact with a free circulation of air. Such rust films could be wiped off with a piece of waste, and the tube sheets and tubes found in exactly the same condition as when they were installed. Thus, the useful life of a boiler and economizer with deaerated water is no longer limited by corrosion. Corrosion has been definitely overcome.

An incidental advantage is found in the fact that the Elliott Deaerator, by insuring a constant temperature of the water entering the economizer, eliminates deterioration of the setting due to expansion and contraction of tubes.

In boilers which have been operated without deaerated water and seriously corroded, the use of deaerated water, corresponding to its action on hot water piping, removes the corrosion products, but at a much slower rate, due to the fact that the corrosion products have been formed



Shop view of 300,000 lbs. per hour Deaerator unit, showing Separator, Main Condenser, Ejectors and Auxiliary Condenser. This view does not show the Jet Heater which is part of the unit.



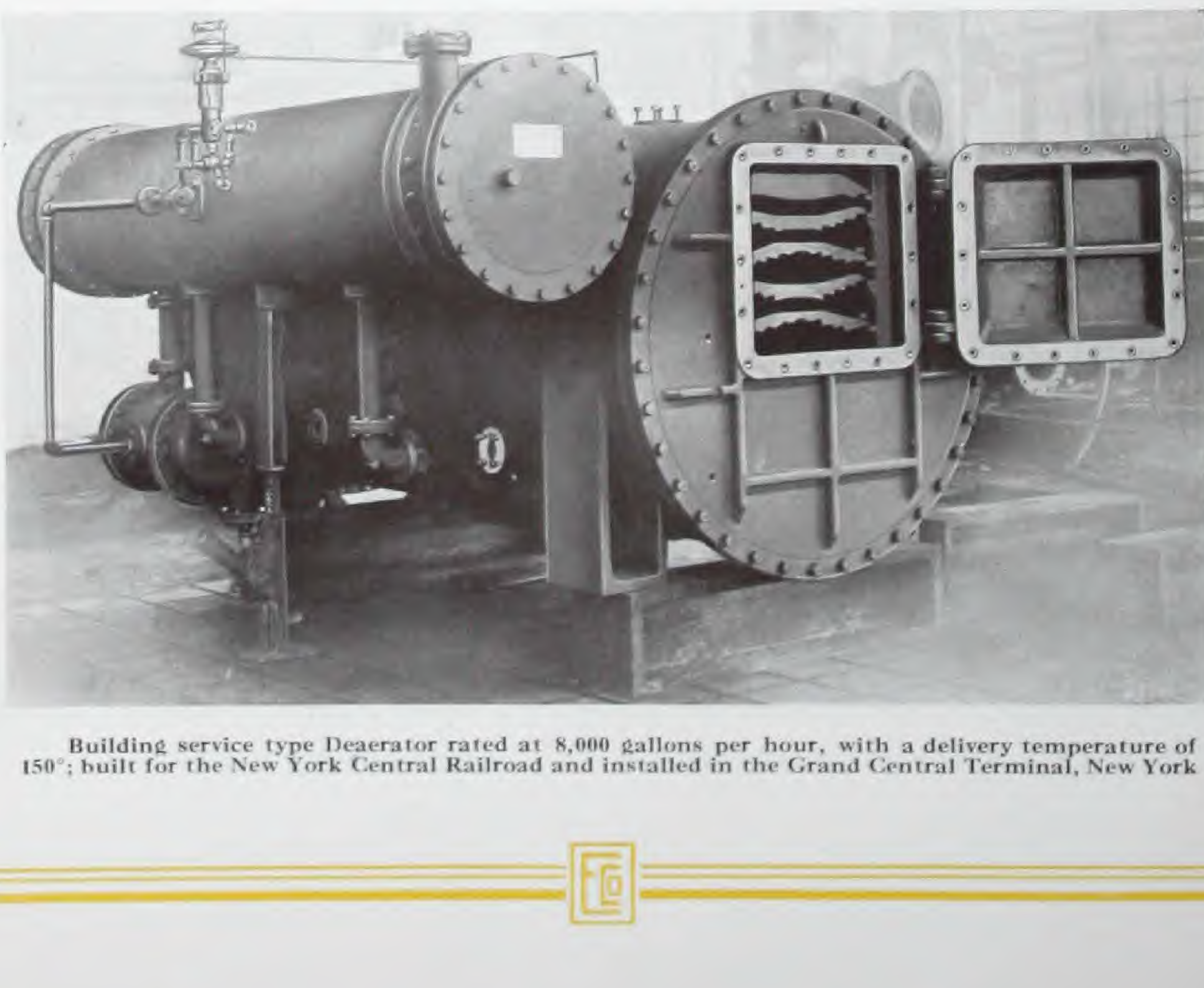
Shop view of 675,000 lbs. per hour Deaerator unit, showing Separator and Main Condenser.

under high temperature and high pressure. However, when the corrosion products detach themselves and render the metal surface of the tube sheets visible, the metal is found to be in a much worse condition than any examination of its surface previously would indicate, showing the need for the deaeration of boiler feed water and demonstrating the fact that without deaeration, boilers are subject to serious pitting and corrosion which is hidden to ordinary inspection. With deaerated water, corrosion positively ceases, rust products are removed, and the life of the boilers is greatly increased.

General

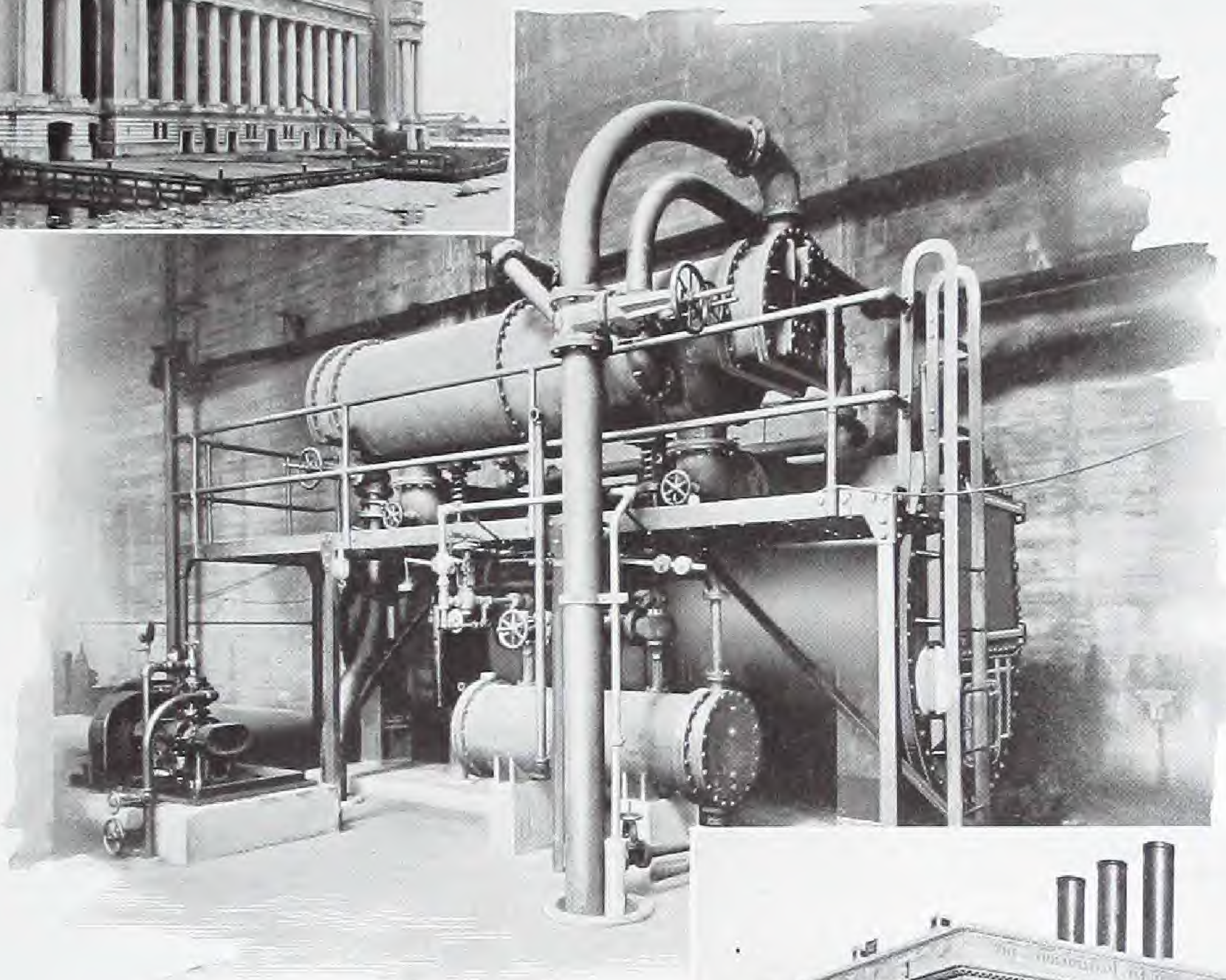
Prevention of corrosion is essentially an insurance feature which has very positive and undeniable advantages. It is also a conservation measure, in which insurance is obtained without risk of loss. Sometimes, in boilers and economizers, it is also a means of securing a higher operating efficiency and a larger return upon a pound of coal.

Deaeration of water in power plants and buildings imposes no new conditions. In the power plant, it adapts itself to all systems of feed water heating with a perfect flexibility and without any accompanying loss in efficiency, since the process in itself, while it operates on heat, is based upon heat interchange and is 100% thermally efficient. Deaeration, therefore, assures complete protection against corrosion, allowing full advantage to be taken of economies of high pressure steel tube economizers and boilers, the lowered investment charges of operating at extremely high ratings, and at the same time, the accommodating of the entire system to conditions which will yield the maximum return upon the investment and maximum efficiency.



Building service type Deaerator rated at 8,000 gallons per hour, with a delivery temperature of 150°; built for the New York Central Railroad and installed in the Grand Central Terminal, New York

Chester Station, Philadelphia Electric Company.



One of the 400,000 lbs. per hour Elliott Deaerators installed in the Delaware Plant of the Philadelphia Electric Company.

At Right: Delaware Station.

Philadelphia Electric Company

Delaware and Chester Stations

DEAERATION has been a paying investment for the Philadelphia Electric Company. At the time of printing this bulletin, seven Deaerator units have been furnished, with a combined capacity of 2,800,000 lbs. of water per hour, completely deaerating the capacity of both stations.

At the Delaware Station, by reducing the temperature of the boiler feed water entering the economizer from 210° to 140° by the expedient of deaerating the water, a saving is effected which it is figured will pay for the Deaerators inside of two years.

A Description of the Process

BRIEFLY, the Elliott Deaeration Process consists of injecting heated water into a region of vacuum, where violent and explosive boiling occurs. This action liberates the dissolved gases, such as oxygen, nitrogen, and carbon dioxide. No heat is wasted in the process and the apparatus is 100% efficient thermally. The heat liberated in the boiling process is recovered in a Condenser, cooled by the incoming water on the way to the Heater. Non-condensable gases are exhausted from the Condenser by an Air Ejector.

The complete apparatus included in the Elliott Deaerator consists of

(*a*) A Heater for heating the water

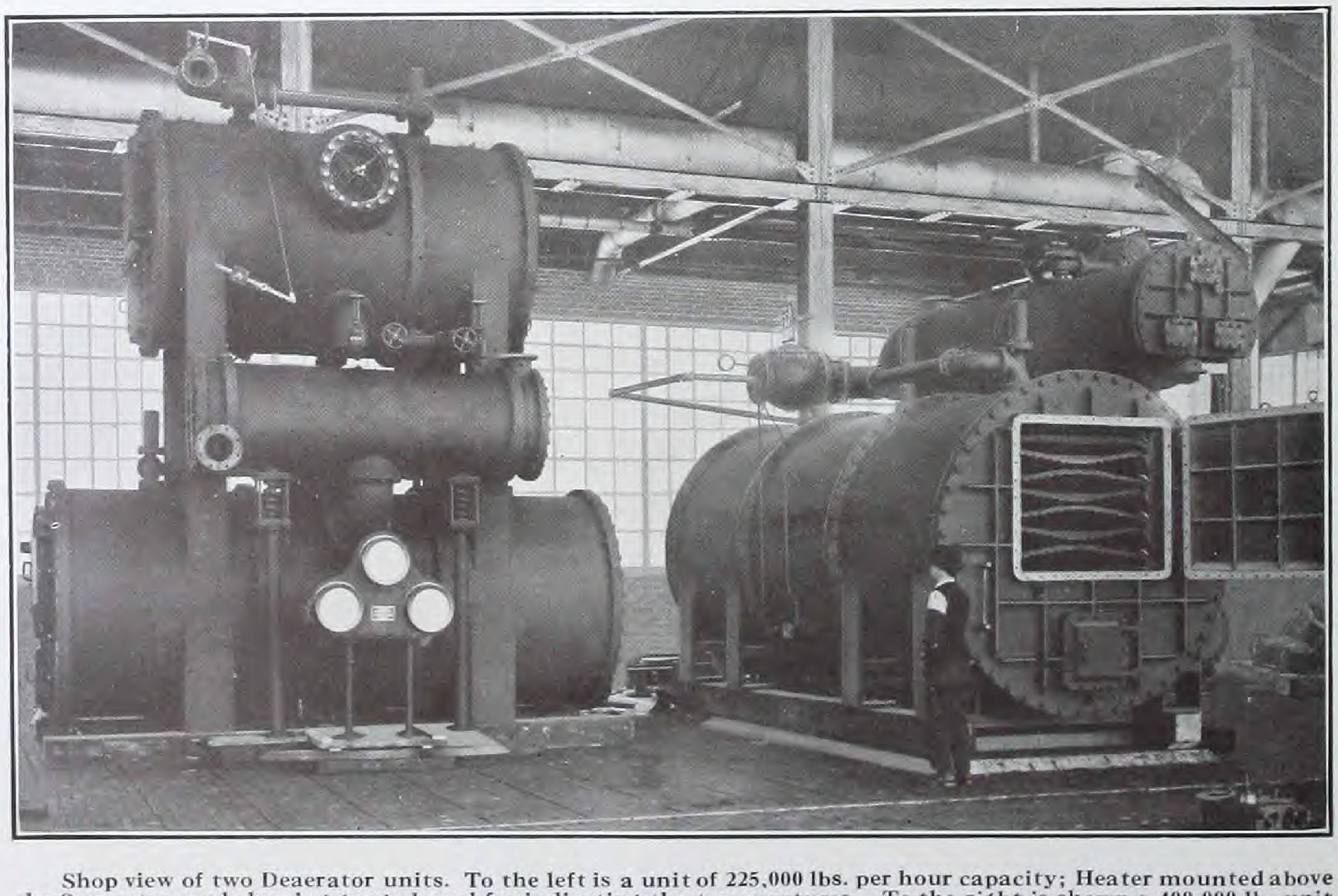
(*b*) A Separator for deaerating it

(*c*) A Condenser for recovering heat and vapor liberated in the process of deaeration.

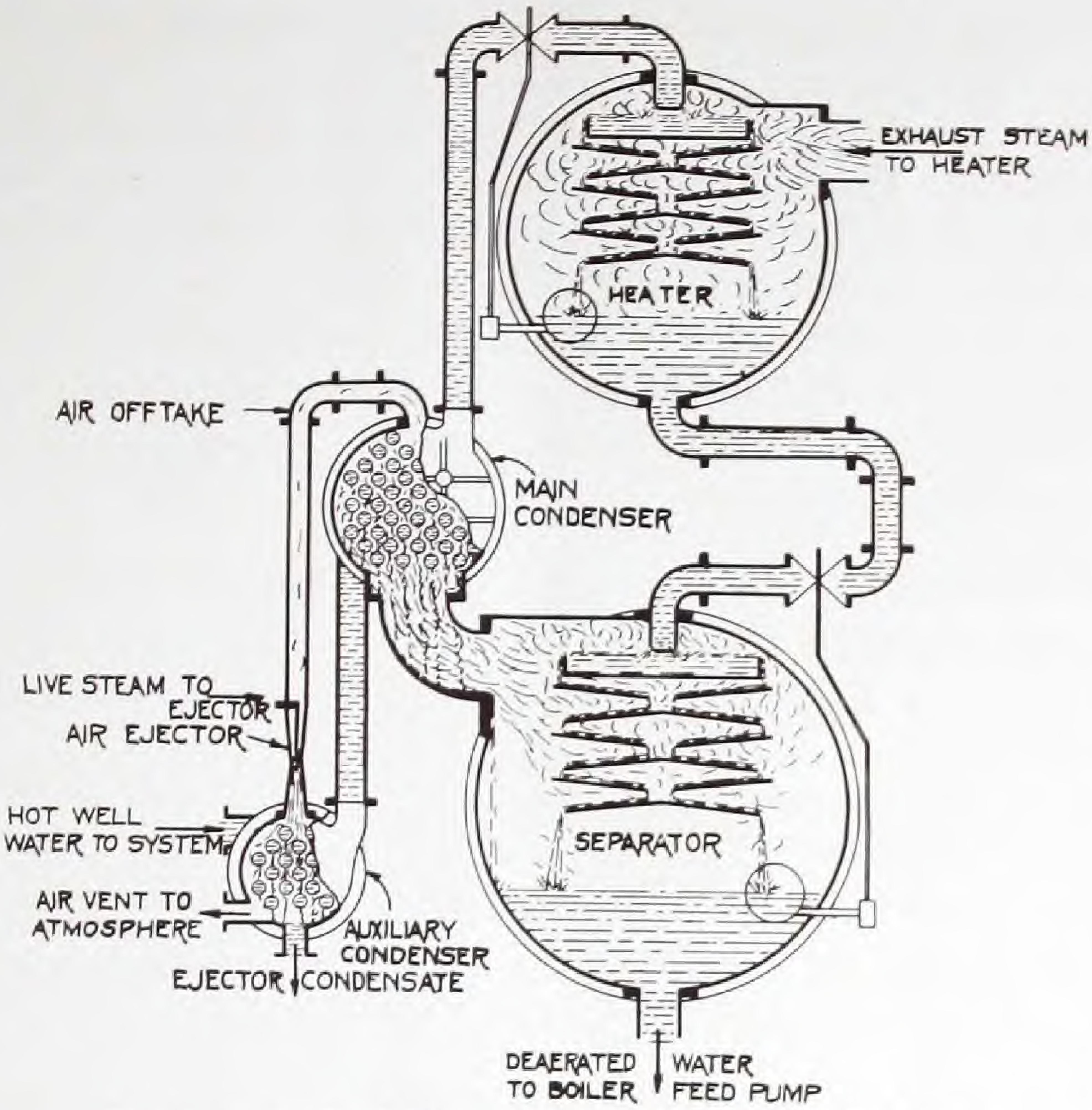
(*d*) An Air Ejector for maintaining the vacuum

(*e*) An Auxiliary Heater or Condenser for condensing the steam from the Air Ejector, where other means are not available.

The diagrammatic sketch, opposite, shows the cycle of operation of the Deaerator. Water drawn from the supply line or hot well circulates through the tubes of the Auxiliary and Main Condensers, which are con-



Shop view of two Deaerator units. To the left is a unit of 225,000 lbs. per hour capacity; Heater mounted above the Separator, and showing gauge board for indicating the temperatures. To the right is shown a 400,000 lb. unit without Heater and designed to deliver zero oxygen at 140° temperature.



Diagrammatic sketch illustrating operation of Elliott Deaerator.

nected in series. It then flows into the Heater, where it is heated to the desired temperature. The heated water flows down into the Separator, which is under vacuum, and this vacuum is always such as to have a corresponding temperature somewhat below that of the entering water so that the water in attempting to come into equilibrium with the conditions in the Separator boils violently, giving off some vapor and throwing out the dissolved gases. The water cascades over the trays and drops into the lower part of the Separator and is pumped off to the boilers, economizer or service lines. The vapor and dissolved gases are carried off through the Condenser, where the vapor is condensed and flows back into the Separator, the non-condensable gases being pumped out by the Air Ejector. The heat from the vapor has thus been returned to the water and the heat in the Air Ejector exhaust is recovered by means of the Auxiliary Heater or Condenser in heating the incoming water.

The Deaerator is extremely flexible, and the arranging of the apparatus depends upon individual conditions. The Deaerator takes the place of an ordinary Feed Water Heater and fits into the plant operation in exactly the same manner. The apparatus may employ either closed or open type of Heater, Jet or Surface Condenser. All of the apparatus is extremely simple, and the process involves no methods or apparatus with which the average operating engineer is not familiar. The appa-

ratus is capable of removing all of the dissolved gases contained in the water. For eliminating corrosion, dissolved oxygen only is usually specified, and guarantees are offered on this apparatus, ranging from zero upward, as the customer may require.

We are prepared to build Elliott Deaerators for power plants in units up to a capacity of 1,000,000 lbs. per hour. For building service, we build them as small as 500 gallons per hour. Illustrations throughout this bulletin show Deaerator units in operation in typical plants in various parts of the country.

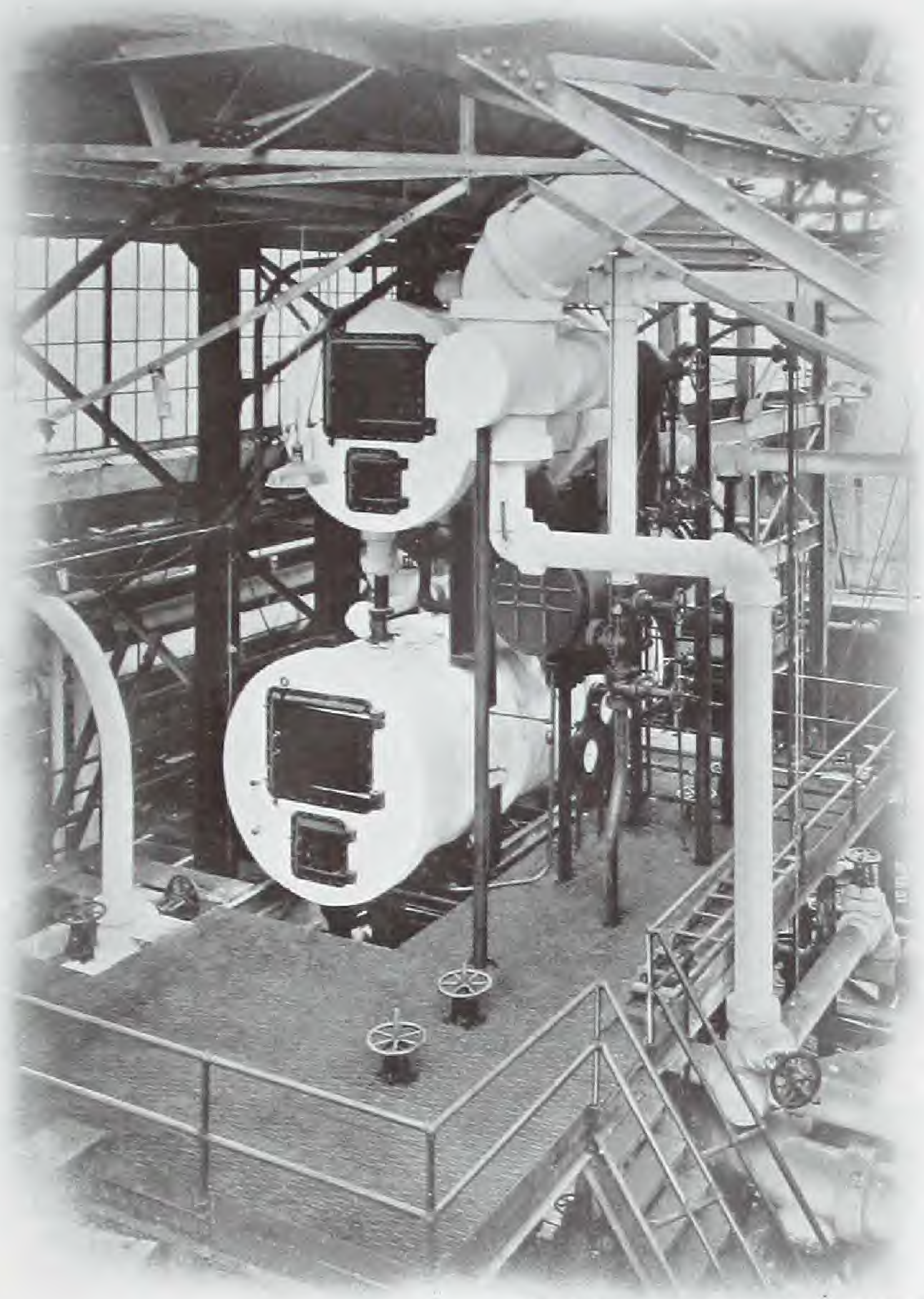
Elliott Deaerators are reasonable in first cost and operating charges are practically nothing. Their use is always justified in connection with hot water lines, regardless of the pipe material. They have clearly demonstrated their efficiency in connection with economizer installations. The most important boiler plants are now using economizers with deaerated water, with full confidence that they can look into the future and be certain of a proper return on their economizer investment, which they could not do before the advent of a successful Deaerator.

Equipment

ELLIOTT DEAERATORS are equipped with a gauge board, on which is mounted one two-pen recording thermometer and a recording vacuum gauge. From the reading of these instruments the performance of the Deaerator is positively indicated, but the use of the instruments is primarily to indicate when operating conditions elsewhere in the plant have interfered with the operation of the Deaerator. The Deaerator itself needs no attention in operation.

Winkler Test Kit in use.

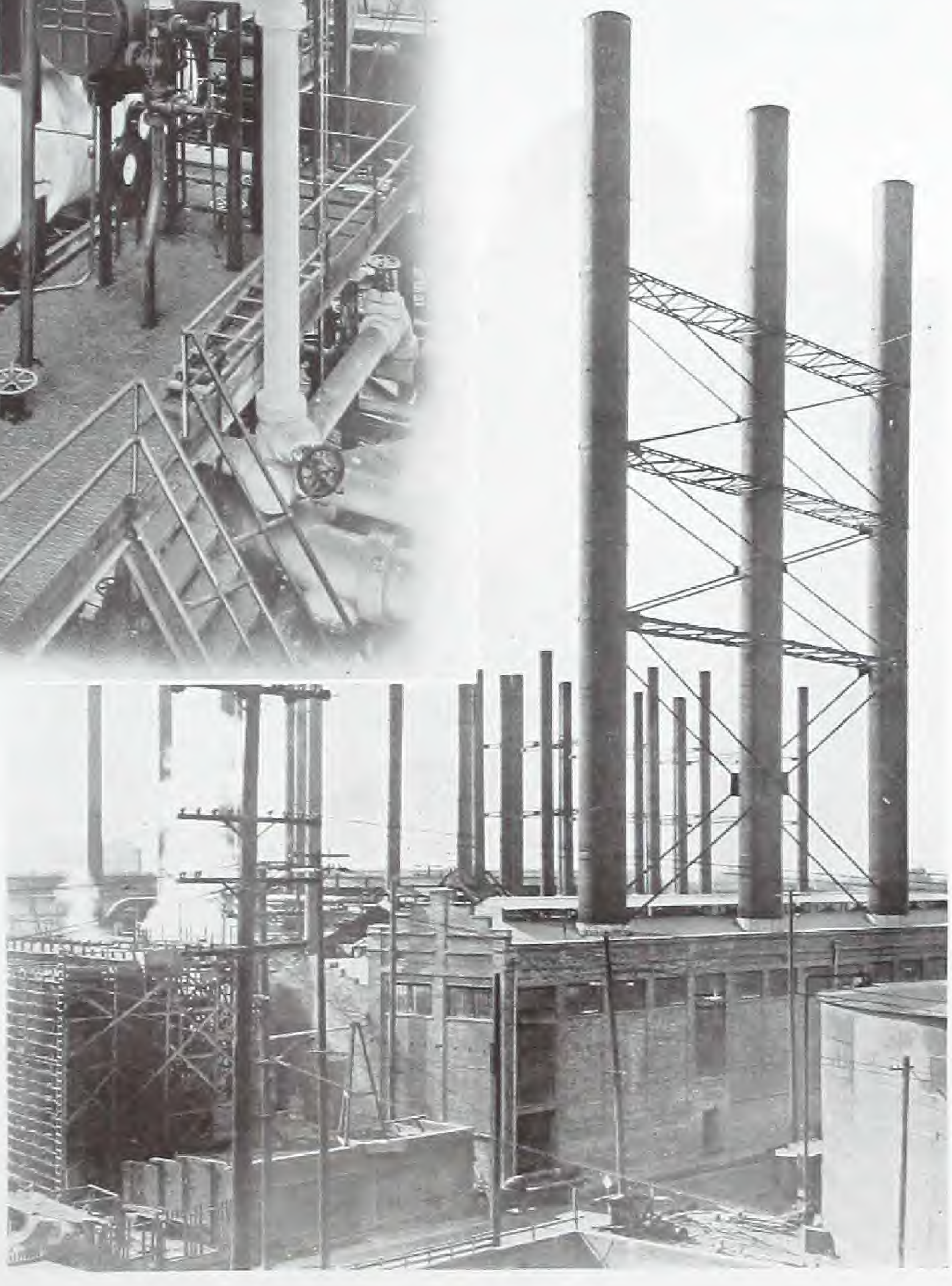
A portable Test Kit containing sufficient chemical apparatus for the performing of oxygen determinations by the Winkler method is furnished with each Deaerator. The manipulation of this Winkler determination is very simple, and anyone not a chemist, following directions given, can easily make the determination.



Los Angeles Gas & Electric Company

Northside Station
Los Angeles, California

225,000 lb. per hour power plant unit.



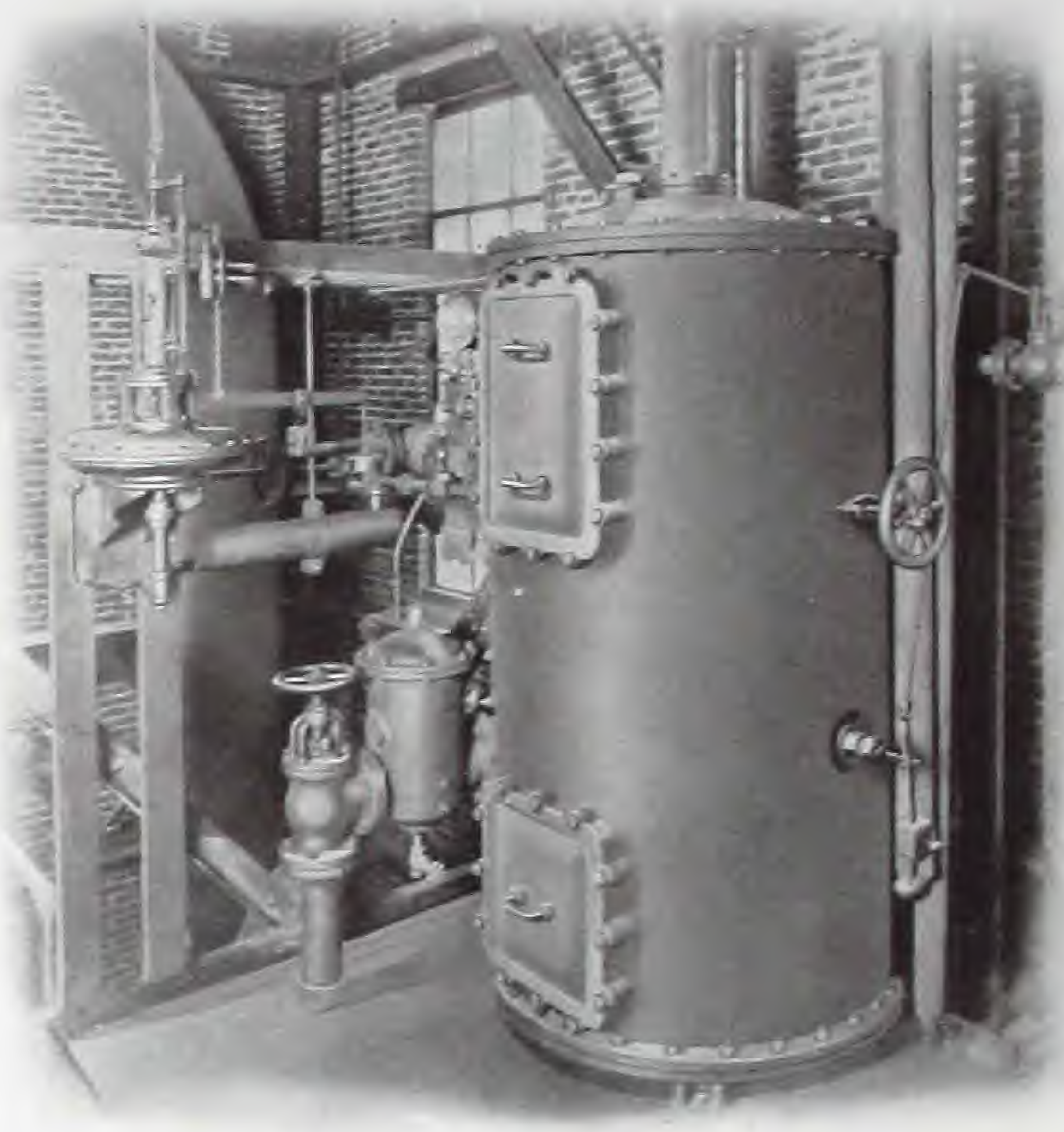
THE illustration above shows one of two 225,000 lbs. per hour Elliott Deaerator units in the Northside or Almeda Street Station of the Los Angeles Gas & Electric Company, Los Angeles, California. A view of the plant is shown at the right.

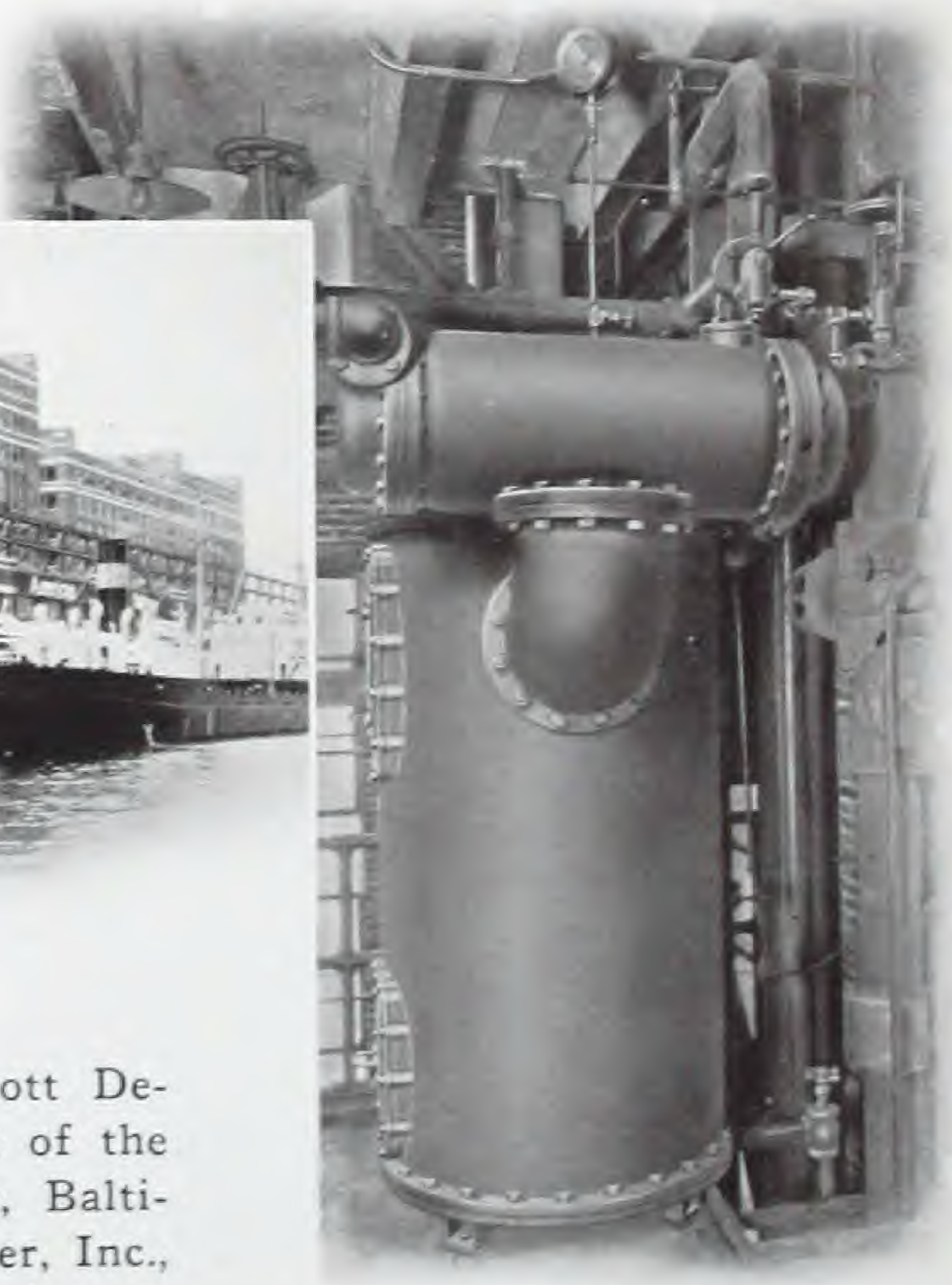
The Deaerators at the Los Angeles Gas & Electric Company, which are rated at 225,000 lbs. per hour capacity each, are serving units 4 and 5 protecting boilers and economizers. At the time of printing this Bulletin, one unit has been in service for some time, giving approximately zero oxygen and more than meeting its guarantee.

The Baltimore Refinery of the American Sugar Refining Company

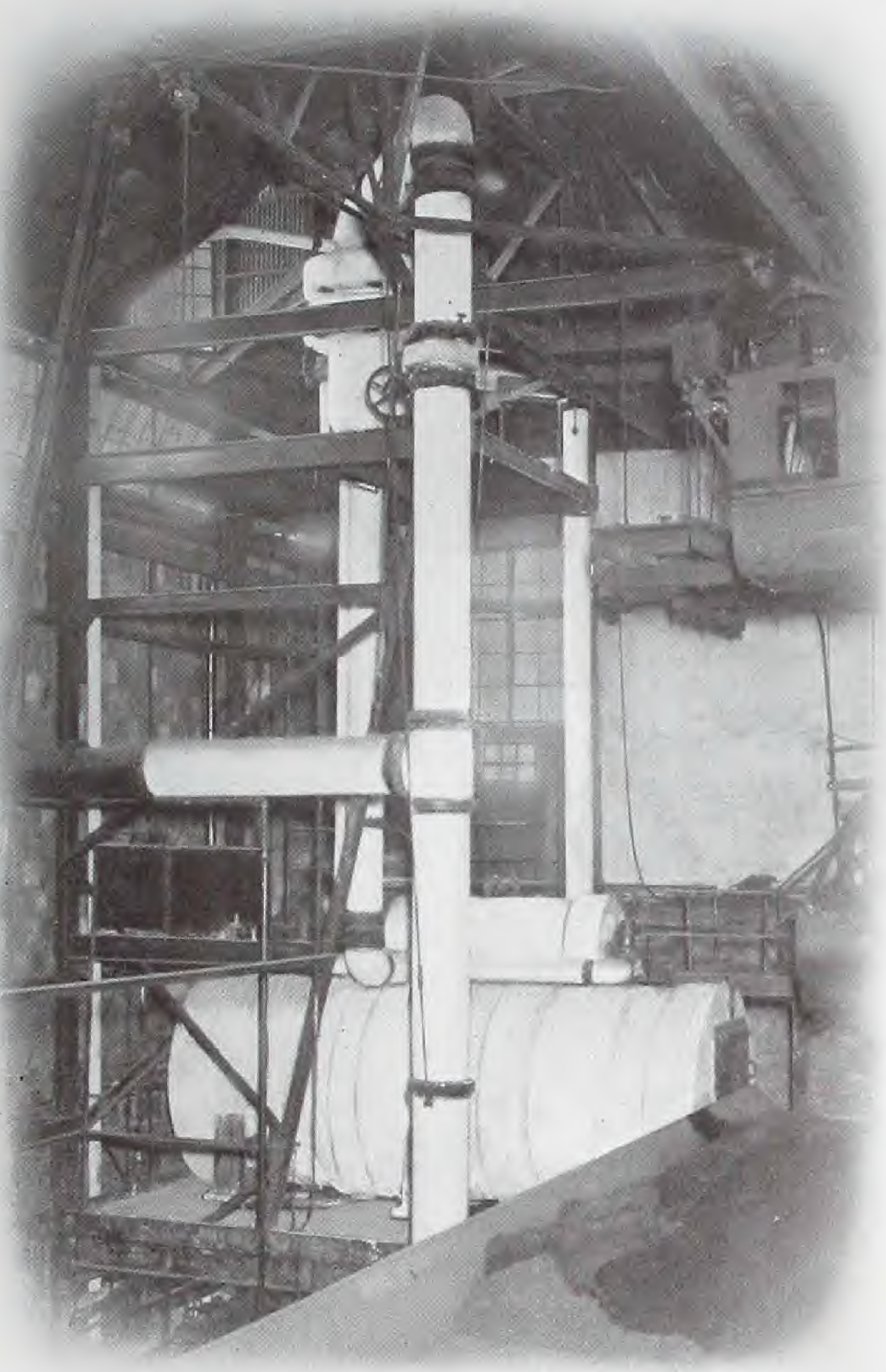
(Stone and Webster, Inc., Builders)

A small vertical power plant type





THE illustration shows the Elliott Deaerator installation in the plant of the American Sugar Refining Company, Baltimore, Maryland, Stone & Webster, Inc., Builders. This Deaerator is installed in two parts on two different floors. The Heater is on the second floor shown above, and the Deaerator or Separator unit with Condenser is installed on the first floor, shown below in the illustration. This unit is of 24,000 lbs. per hour capacity operating on make-up water only and serving boilers and economizers. The plant view is of the Baltimore Refinery of the American Sugar Refining Company.



New York Steam Corporation

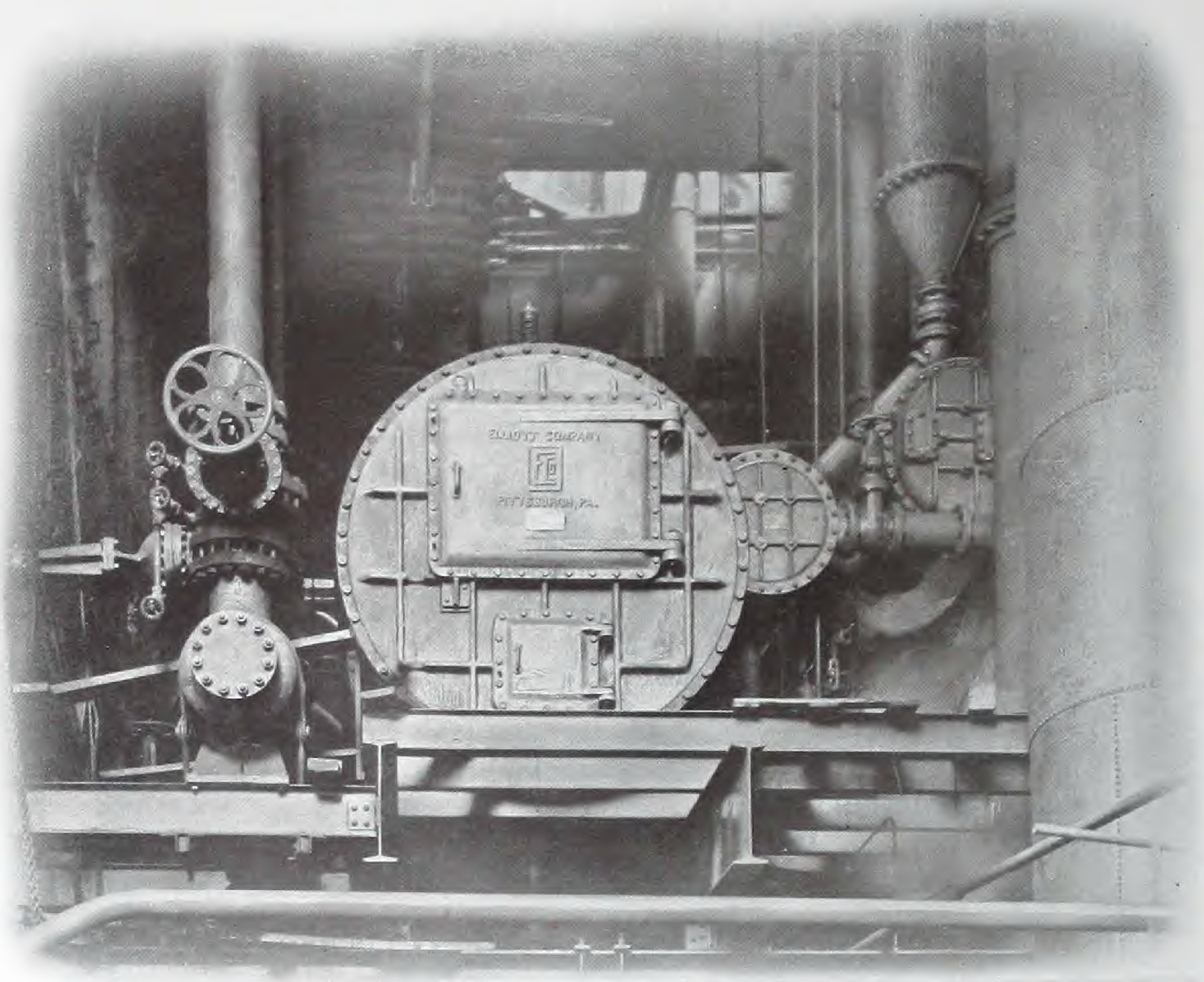
Station J

59th Street and East River

(Frederick Pope, Consulting Engineer)

300,000 lb. per hour power plant unit with Jet Heater

ELLIOTT Deaerator installation in the plant of the New York Steam Corporation, Station J, 59th Street and East River, New York City, under the Queensboro Bridge (view of the plant at the right). The unit is of 300,000 lbs. per hour capacity protecting the entire station including boilers and economizers; it operates at a minimum temperature of 170°. It is equipped with a Jet Heater. This unit deaerates the water which is sent to economizer type boilers supplying steam to the north end of the loop of the New York Steam Corporation for heating and industrial service.

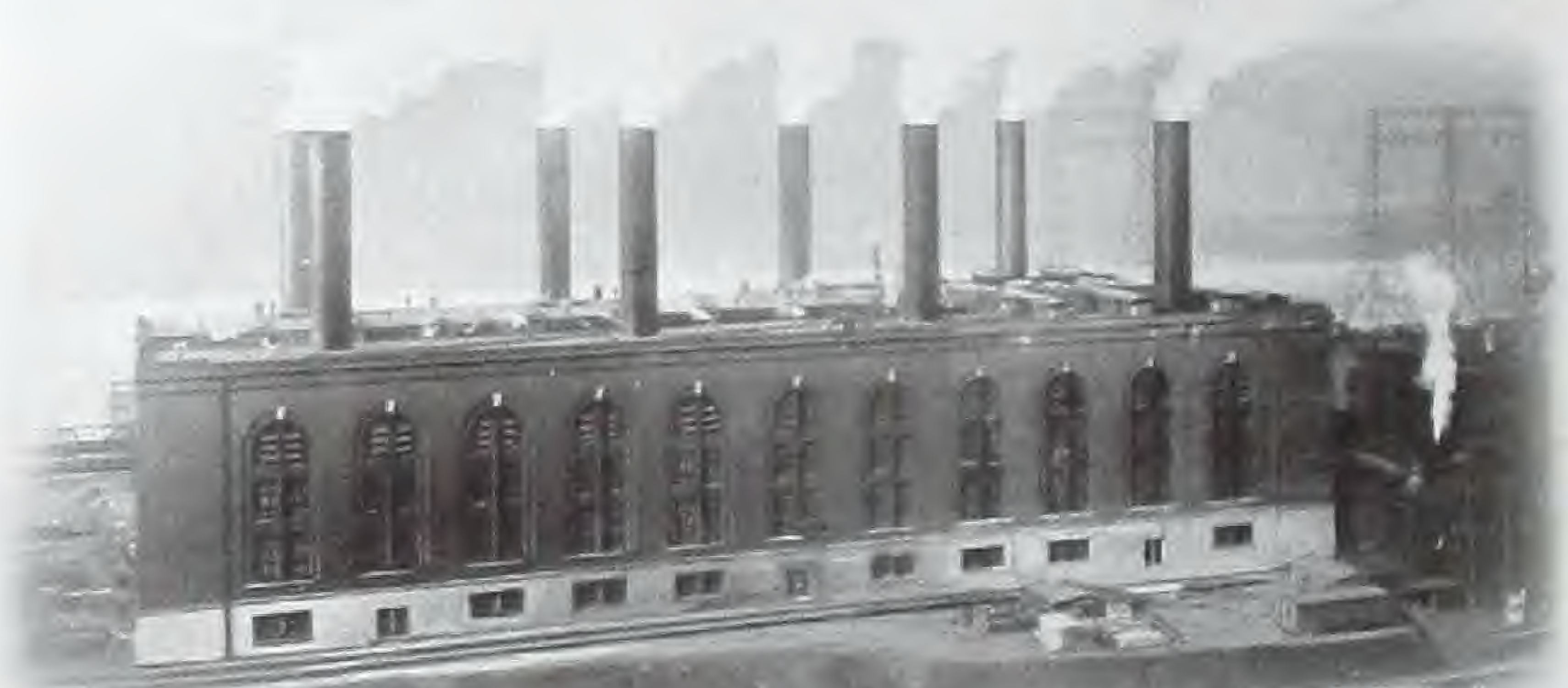


West Penn
Ohio Power Company

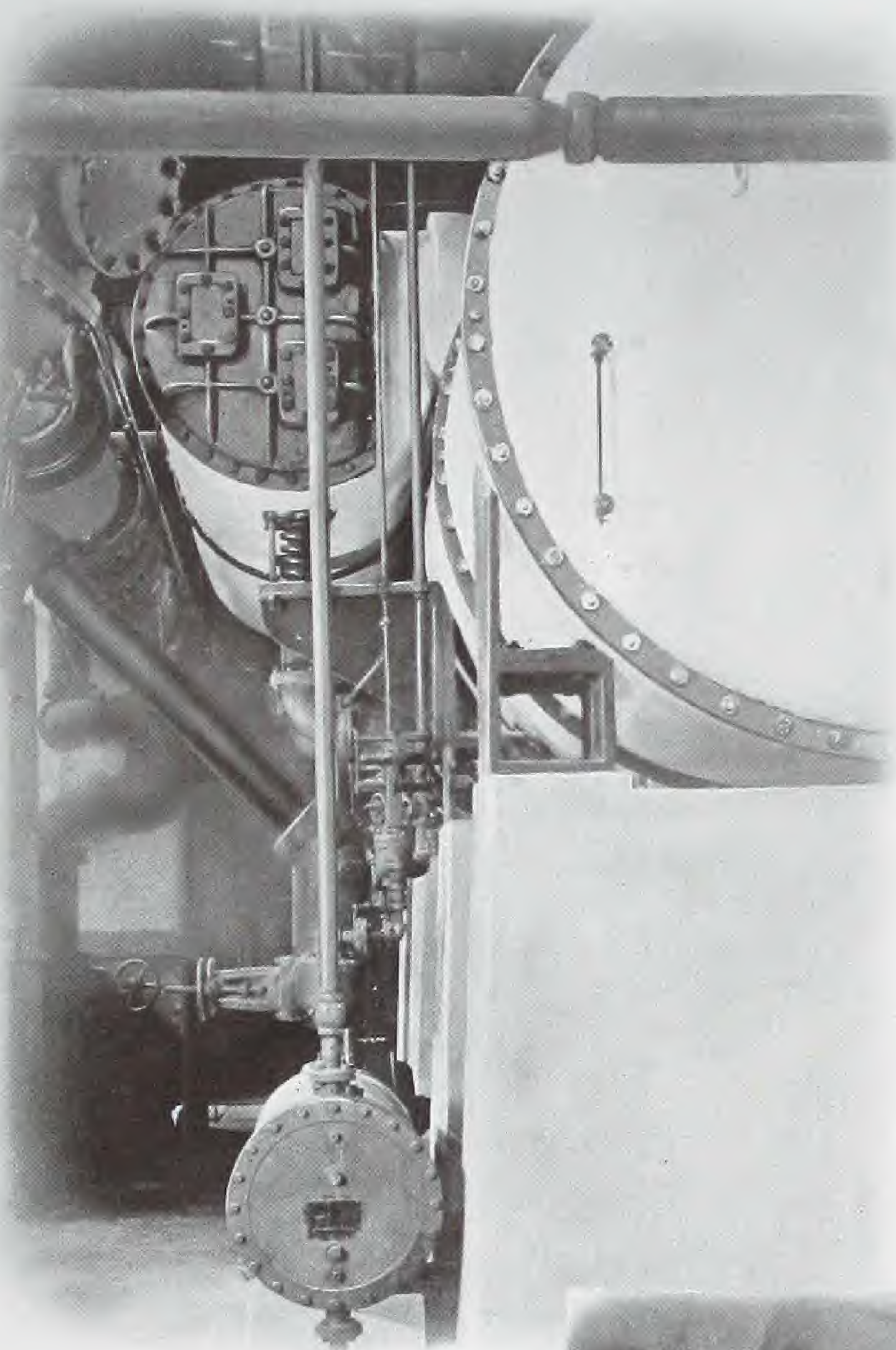
Windsor Station
Power, W. Va.

(Sanderson & Porter, Engineers)

350,000 lb. per hour power plant unit.



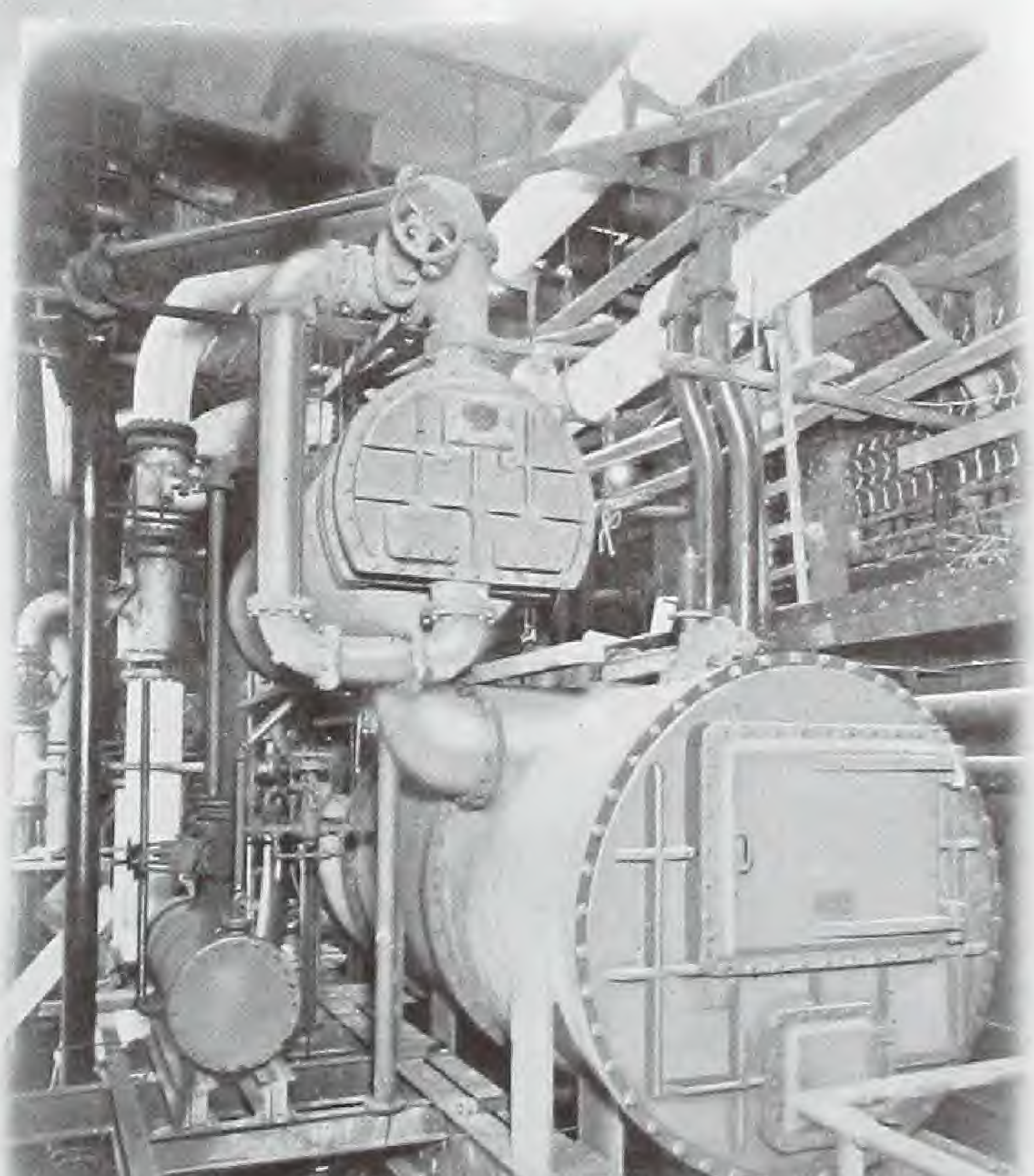
ONE of two Elliott Deaerators installed in the Windsor Station of the West Penn-Ohio Power Co., Power, W. Va.—(Sanderson & Porter, Engineers)—This station, which is one of the largest in the country (180,000 K. W.) is shown in the photograph at the right. The deaerators are rated at 350,000 lbs. per hour and serve units 5 and 6, protecting boilers and economizers. The illustration shows the Separator, Main Condenser, Extraction Heater and tail pipe from the Jet Heater (not shown) for unit No. 6.



Pennsylvania Power & Light Co.

Hauto Station

This Unit is of 900,000 lbs. capacity. It protects the entire station, boilers and economizers, both of the steel and cast iron tube type. The unit has at times carried a load of 1,100,000 lbs. per hour, with an oxygen content of .04 and a water temperature of 180°.



Commonwealth Edison Co.

Chicago, Ill.

Calumet Station

(Sargent & Lundy, Engineers)

One of the 350,000 lbs. per hour Deaerator units furnished this station. Four such units are used, protecting boilers and economizers.

ECO